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GB 0817538 A GB 0674967 A GB 0462352 A
US 4087105 A US 4078816 A US 3811704 A

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(71) Applicant(s)
Terry Thomas Cook
29 Orchard Way, Barnham, West Sussex, PO22 0HX, United Kingdom

(72) Inventor(s)
Terry Thomas Cook

(74) Agent and/or Address for Service
Terry Thomas Cook
29 Orchard Way, Barnham, West Sussex, PO22 0HX, United Kingdom

(54) Human powered hydraulic drive system

(57) A human powered hydraulic drive system uses foot or hand driven oscillating cranks or levers 11 to produce pulsating pressure signals between a pair of semi-rotary transmitting actuators 12,14 and a pair of semi-rotary receiving actuators 17,20. The motion of the receiving actuators is converted by freewheeling clutches into uni-directional rotation of a driven shaft 18. A pressure transformation sub-system can be incorporated to vary the system gain. The system is particularly suitable for driving a bicycle but may also be used to produce rotation in shafts and axles of other wheeled personal transport, airscrews, machinery and exercising equipment.

Fig.1

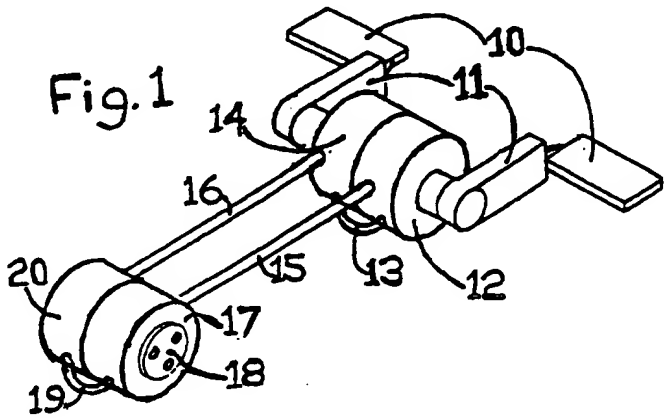

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Fig. 1

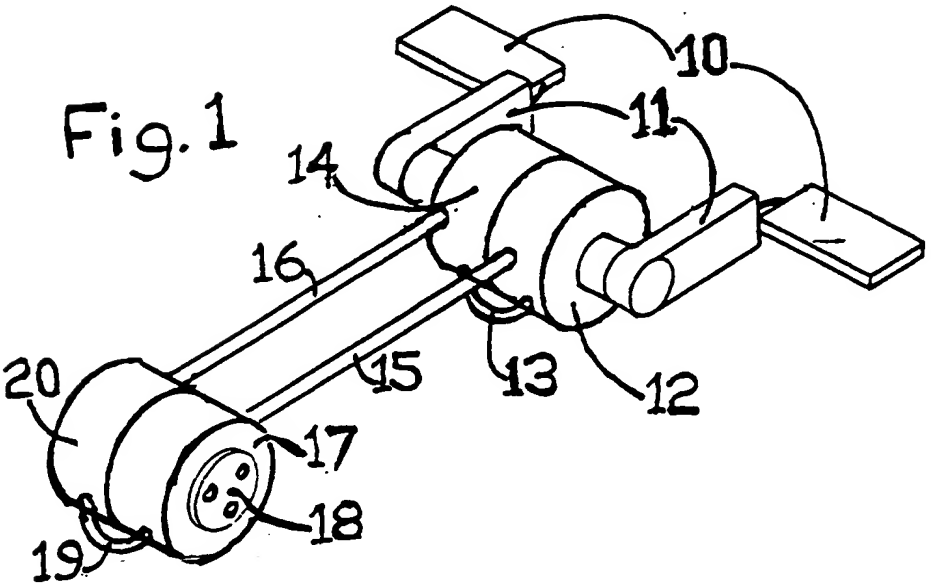

Fig. 2

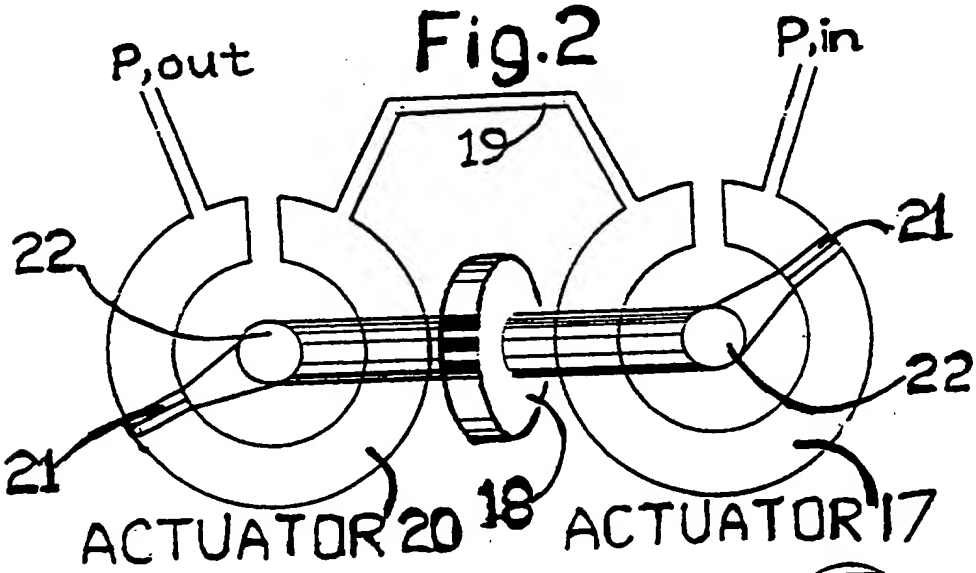

Fig. 3

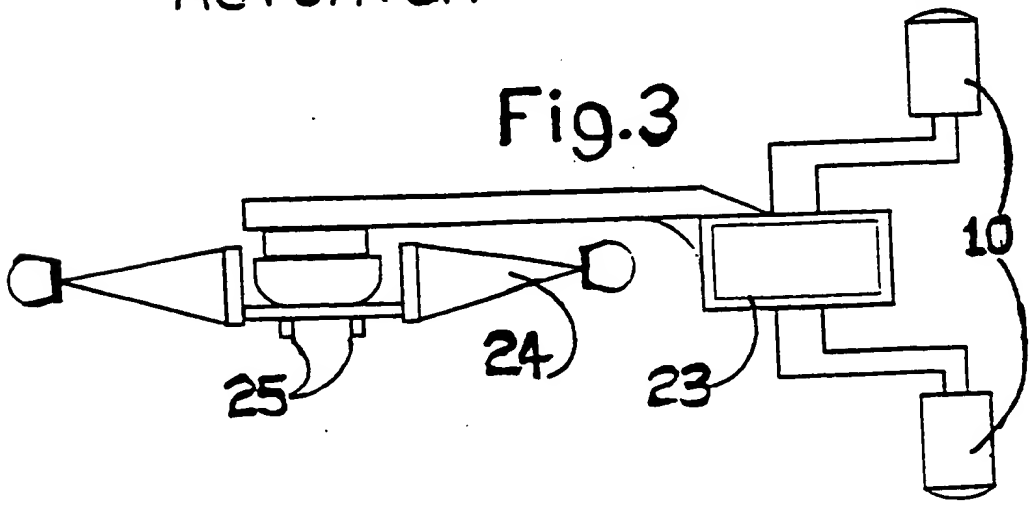

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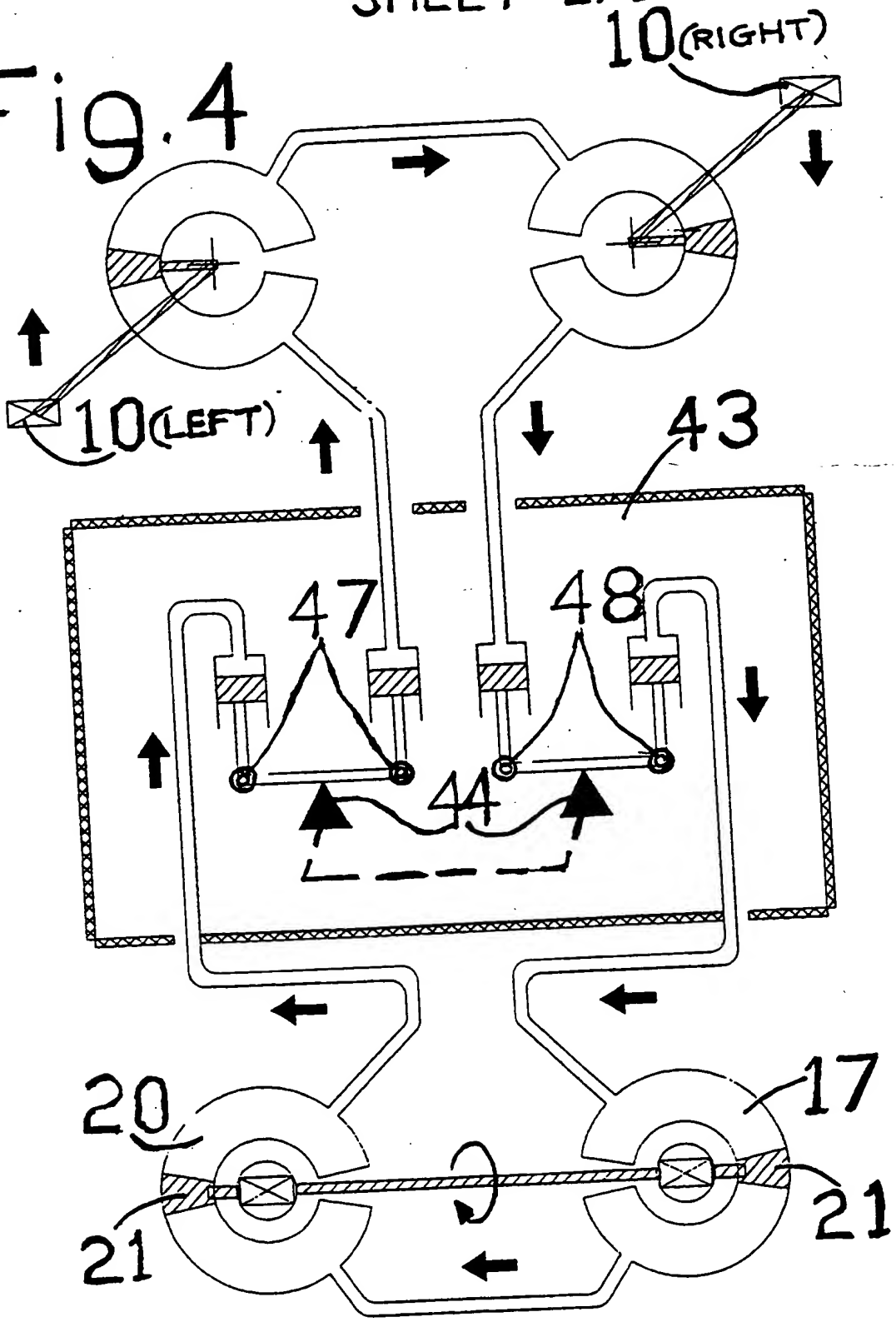
Fig.4



HUMAN POWERED HYDRAULIC DRIVE SYSTEM

This invention relates to the application of a hydraulic drive system tor human powered machinery, personal transport and exercise equipment.

The history of the bicycle and pedal operated machinery can be traced from the early 1880's with early machines manufactured commercially by the Coventry Sewing Machine Company. Earlier examples of equipment operated by foot may be drawn from recorded data on wood lathes operated by artisans such as wheelwrights and chair makers. More up to date examples may be drawn from the use of tradesmens/invalid carriages and the field of human powered flight with the Kremer cross-Channel flight prize awarded in 1979.
The most successful bicycle drive system has been by the well known drive means of causing the rear wheel to rotate via a chain drive. The chain is usually linked between the rear wheel cog and a Chainwheel and pedal set. By pressing on the pedals the cyclist imparts a torque to the chainwheel and ultimately the rear wheel causing forward travel of the bicycle and its rider. In general this principle of causing pedal and crank rotation to drive a chain or belt is used on the majority of modern equipment.

The explanation of the features of this invention will use, in the main, examples drawn from the field of cycling and bicycles; however the technology employed is equally applicable to all human powered machinery.
According to the present invention a hydraulic drive system is utilized to produce rotary motion. The conventional method of pedal operation is dispensed with and continuous rotation of the pedal cranks is not required. Instead of continuous pedal rotation, each pedal is restricted to a quasi-reciprocating movement . This motion occurs solely within the 1st and 4th geometrical quadrants and between the approximate angular positions of 80 degrees, and clockwise to 280 degrees inclusive. An important feature is evident however, in that it is possible to operate the pedal cranks over smaller arcs of travel about the horizontal zero degree position where the greatest torque may be applied.
It is arranged that as one pedal is moved clockwise from say 80 degrees to 280 degrees the other pedal is moving anticlockwise, simultaneously from 280 degrees to 80 degrees. At one stage both pedals will be at an angular position of zero degrees. From this centralized position the pedals are constrained to move in opposite directions. The pedal cranks are attached to hydraulic rotary activators of a type which may be used singly or in multiples coupled to a common drive shaft.

It is a feature of the invention, that in following the locus of motion, the feet/legs are not required to trace out a circular path, but rather to carry out physical movement in a more vertical line of action, more akin to the motion required to ascend a flight of stairs. Thus when say the right foot is decending the left foot is ascending from the the lowest position through an arc of approximately 160 degrees. In comparison the feet of riders of conventional chainwheel machines travel clockwise and continuosly through a complete circle of 360 degrees.

To recapitulate, this invention requires the the cyclists feet to travel within 160/360 of the active locus required by a conventional chain driven bicycle, i.e. approximately 45%. It is noteworthy to mention, however, that the total useful torque input that can be exerted by the push of a Human leg/foot combination can only be just after top dead centre (TDC) to a position just before bottom dead centre(BDC) of the crank; for clockwise rotation. Therefore it would seem that efficiency of movement would obtain if the foot could be returned through a shorter distance to a position where pedal pressure and hence torque input could be repeated.

The hydraulic drive system used in this application comprises of two hydraulic actuators coupled mechanically, one to each pedal crank. However, a single hydraulic coupling means is used between the actuators to ensure synchronization , that is to say to provide the opposing motion of the pedal cranks as previously described. In addition each hydraulic actuator has an output conduit available to supply pulsating (or "Push-Pull") hydraulic pressure signals. These pressure signals may be coupled to freewheeling rotary actuators within the hub of the front and/or rear wheel of the bicycle. Further it is possible to switch pressure signals between front wheel drive (FWD) only, rear wheel drive only, or both.

The foregoing differs from more traditional two-wheel drive means, such as chains, push-rods or drive cables, where torque input to the FWD is slaved from the rear wheel. A main feature of this embodiment is is that the drives to the front and rear wheels are completely independent and decoupled. In addition, as the hub rotary actuators contain freewheel mechanisms; the wheels are allowed to rotate at at different speeds, as would be required when negotiating a sharp bend.

It is a general characteristic of hydraulic systems, for pressure signals to have the same amplitude in all parts of the closed system. It follows therefore, that in an operational mode where both bicycle wheels are driven hydraulically, the torque at the hubs will be equalized. In certain other traditional systems, where FWD is via a chain or shaft drive coupling means slaved from the rear wheel, frictional losses would be evident which would tend to cause lower drive capability on the front wheel compared to the rear wheel.

In certain embodiments of this invention it is possible to modify the system pressure signals by the use of a hydraulic pressure transformer. The transformer is capable of adjustment to provide different ratios between the angular rotation of the riden cycle's wheels and the reciprocating motion of the cyclists feet.

Although the foregoing uses a two-wheeled machine as an exemplar for the production of rotary motion from action of the human leg muscles, it is of course possible to produce similar action with the arm muscles, thus providing a transport drive alternative for people who are physically challenged and reliant on wheelchairs and tricycles.

The technology will also find applications in Human powered aviation where the air-screw motors (hydraulic actuators) may be placed in novel positions which would be impractical if the airscrews were driven by long lengths of drive chain or shafts.

Another application suitable for this hydraulic drive system would be as a resistive device in an exercise machine. Various degrees of Human effort to produce motion can be programmed by the introduction of restrictors in the hydraulic conduits.

A specific embodiment of the invention will now be described by way of example with reference to the accompanying drawing in which:-

Figure 1 - shows in perspective a basic bicycle hydraulic drive system.

Figure 2 - shows in schematic form a hydraulically coupled pair of actuators.

Figure 3 -shows in simplified plan view the system in Fig.1 fitted to a "swinging arm" type of suspension unit.

Figure 4 - shows a schematic of a hydraulic drive system fitted with a pressure adjusting transformer.

Refering to the drawing Fig.1, the hydraulic drive system consists of a pair of hydraulic actuators 12 and 14, which are driven by the pedals 10 via the cranks 11. A conduit 13 provides a channel for hydraulic pressure to synchronize the motion of the actuators and hence the motion of the pedal cranks. Pressure pulses from the actuators 12 and 14 are fed via conduits 15 and 16 to the wheel drive actuators 17 and 20. Pistons within 17 and 20 provide a drive through freewheel mechanisms to produce rotation of the hub bearing unit 18. In order to balance the synchronized pedal cranks, a conduit 19 gives a similar function to 13. This synchronizing action is depicted in schematic form by Fig.2. Fig.2 shows that a pressure pulse "P"in to ACT-1 will ultimately cause a corresponding pulse "P"out from ACT-2 . However the pistons 21,which could be of round or rectangular cross-section, will maintain their relative angular positions to each other. When operating normally "P"in and "P"out are continually alternating according to the hydraulic pressure pulses provided by the pedal cranks; this oscillatory motion is translated into continuous rotation of the hub 18 via freewheeling clutches 22 between the pistons 21 and hub 18. Fig.3 shows a simplified plan view of a typical arrangement of a pair of pedal driven actuators and wheel drive actuators assembled as a "swinging arm" unit. The central part of the arm construction 23 is attached to the bicycle framework via suitable swivels. The driven wheel 24 may be detached from the hub by the release of screw attachments 25.

With reference to Fig.4, a schematic layout is shown for a complete drive system with the added refinement of a pressure transformation sub-system. If a pressure signal is applied to pedal 10(Right) it may be seen that the flow direction of the arrows will result in pedal 10(Left) moving in the opposite sense. It may be seen in tracing through the pressure signal flow path that a tranformation of the flow rate can take place in the pressure transformer 43; dependent on the set position of the ganged fulcrums 44 as points 47 and 48 are pin joints. The rotary actuators 17 and 20 are allowed to take rotational effort from the system as previously described.

CLAIMS

1 A hydraulic drive system which may be used to produce rotary motion in Human powered wheeled transport systems such as bicycles, invalid carriages, Human powered aviation and other machinery using leg or arm muscles.

2 A hydraulic drive system as claimed in claim 1 which uses at least one Human powered reciprocating and synchronized hydraulic actuator driven by cranks or levers to drive other hydraulic actuators which use freewheeling clutches to produce rotary motion in one direction only.

3. A hydraulic drive system as claimed in claim 1 or claim 2 which uses two input cranks working in opposition in the 1st and 4th geometric quadrants which may be operated closely about the hozontal zero degree position or within any greater arc between the limits of 80 degrees and clockwise to 280 degrees.

4. A hydraulic drive system as claimed in claim 2 or claim 3 where the pressure signals generated by a human powered hydraulic actuator may be applied to one or more rotary hydraulic actuators in a common or different locations.

5. A hydraulic drive system as claimed in claim 4 where the pressure signals generated by a human powered hydraulic actuator may be varied in amplitude by selective gain in a transformer sub-system.

6. A hydraulic drive system substantially as described herein with reference to figures 1 - 4 of the accompanying drawings.

The Patent Office

Application No: GB 9621342.6
Claims searched: 1-6

Examiner: Brian Denton
Date of search: 23 May 1997

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B7E (EDTF)

Int Cl (Ed.6): B62M 19/00

Other:

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	GB 817538	(J.I.GEORGE) whole document	1 at least
X	GB 674967	(J.A.DUNLOP) whole document	1 at least
X	GB 462352	(Dr.B.S.BHARADE) see particularlylines 43-80, page 1	1 at least
X	US 4087105	(AMARANTOS) see lines30-34, column 2 and lines 5-22, column 3	1 at least
X	US4078816	(SMITH) note figures 4-8	1 at least
X	US 3811704	(GREGORIC) whole document and especially lines 1-15, column 3	1 at least

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